



Next Generation GNSS Bistatic Radar Receiver

Presenter: Chris Ruf, University of Michigan

PI: Chris Ruf

Team Members: Roger Backhus, Tim Butler, Chi-Chih Chen, Scott Gleason, Ryan Miller, Andrew O'Brien, Line van Nieuwstadt

Program: IIP-16

ESTR2021
Virtual Series

The Water Cycle

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SUMMARY



- The Next Generation GNSS Bistatic Radar Receiver (NGRx) has been developed under a NASA ESTO IIP program to significantly enhance the current capabilities of GNSS-R receivers and enable new and improved science observations
- **OUTLINE**
 - Motivation for GNSS-R Measurements
 - Examples of Current Capabilities and Observations
 - NGRx Development Status
 - Next Steps

Improved Time & Space Sampling with Low Microwave Frequencies at Low Cost

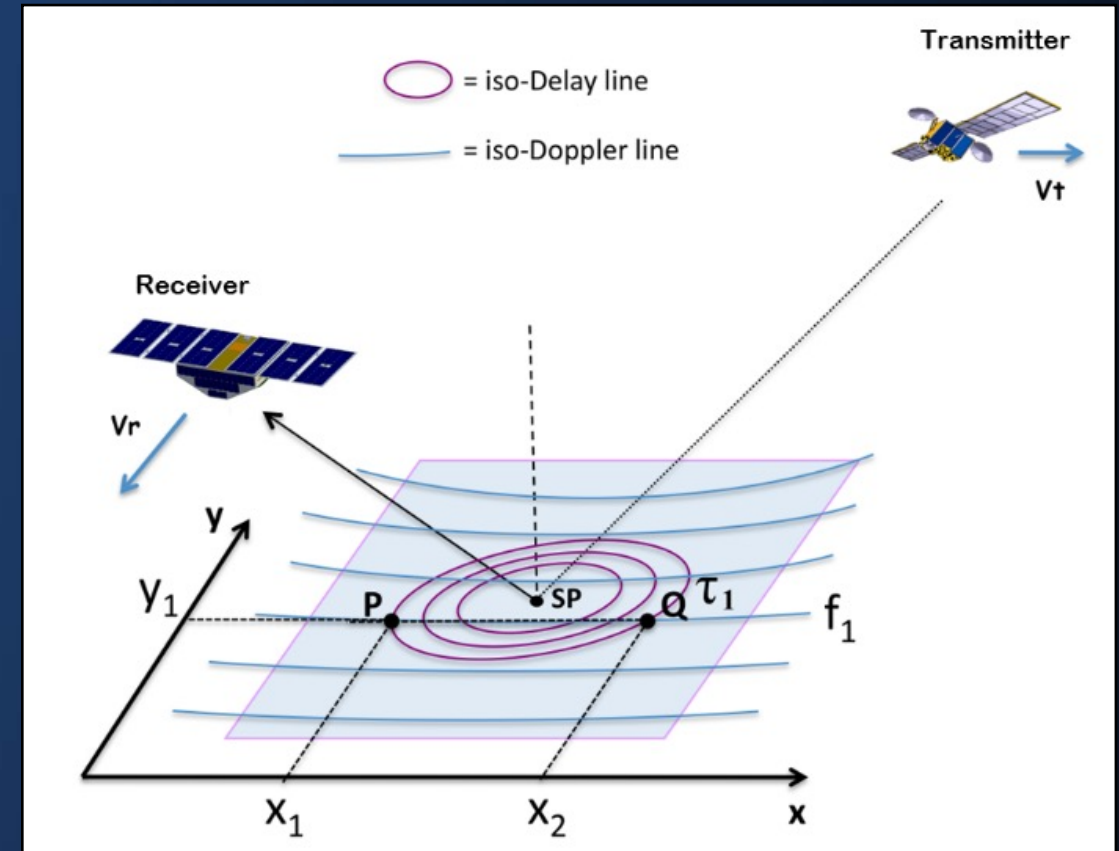


- Why low microwave frequency remote sensing?
 - Insensitive to gaseous attenuation in atmosphere
 - Propagation through precipitation and vegetation canopy
 - Sub-surface penetration (soil moisture, ice thickness)
- Why high temporal sampling?
 - Resolve short time scale events like tropical cyclone winds, extreme precipitation, flooding
- Why high spatial resolution + low cost are difficult
 - Diffraction limited antenna size, high bandwidth/high power radar
- Why high temporal resolution + low cost are difficult
 - Requires many satellites if in low Earth orbit

Solution – GNSS-R Bistatic Radar



- Use GPS constellation as transmitter half of radar
 - 1.6 GHz, 19 cm wavelength
- Adapt GPS navigation receiver to measure signal scattered from surface back into space
 - Uses very low cost, low power mature commercial technology
 - Radar receivers can be accommodated on small, low cost spacecraft



CYGNSS Earth Venture Mission uses GNSS-R Obs



- **Original Mission Objectives**
 - Measure ocean surface wind speed in all precipitating conditions with sufficient frequency to resolve tropical cyclone rapid intensification
- **Flight Segment Design**
 - Eight satellites in low earth orbit at 35° inclination
 - Each s/c carries a modified commercial GPS receiver for bistatic radar measurements of GPS signals scattered by the Earth surface
- **Mission Timeline**
 - Launch 15 Dec 2016
 - Phase E start Mar 2017
 - Currently in extended Phase E

CYGNSS Obs Examples

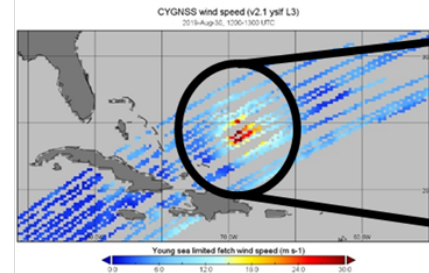
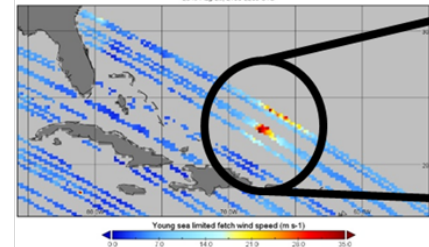
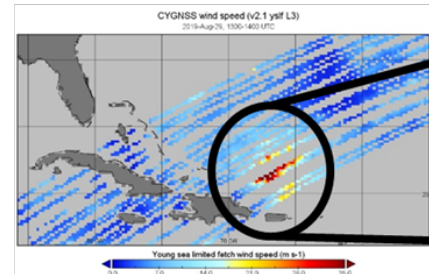
Overpasses of Hurricane Dorian, 2019 Aug 29-30



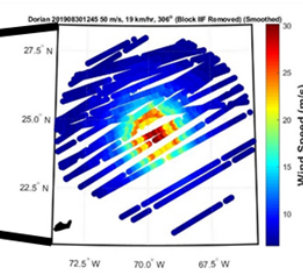
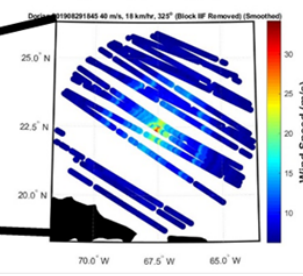
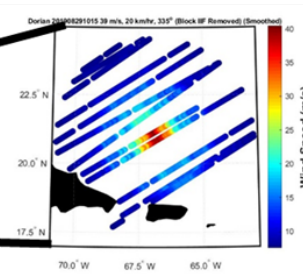
Intensity and storm center

- **2019-08-29, 10:15 UTC**
 - Vmax = 39 m/s
 - Center fix (20.96N, 293.12E)
- **2019-08-29, 18:15 UTC**
 - Vmax = 40 m/s
 - Center fix (22.30N, 292.38E)
- **2019-08-30, 12:45 UTC**
 - Vmax = 50 m/s
 - Center fix (24.43N, 290.26E)

hourly background wind field

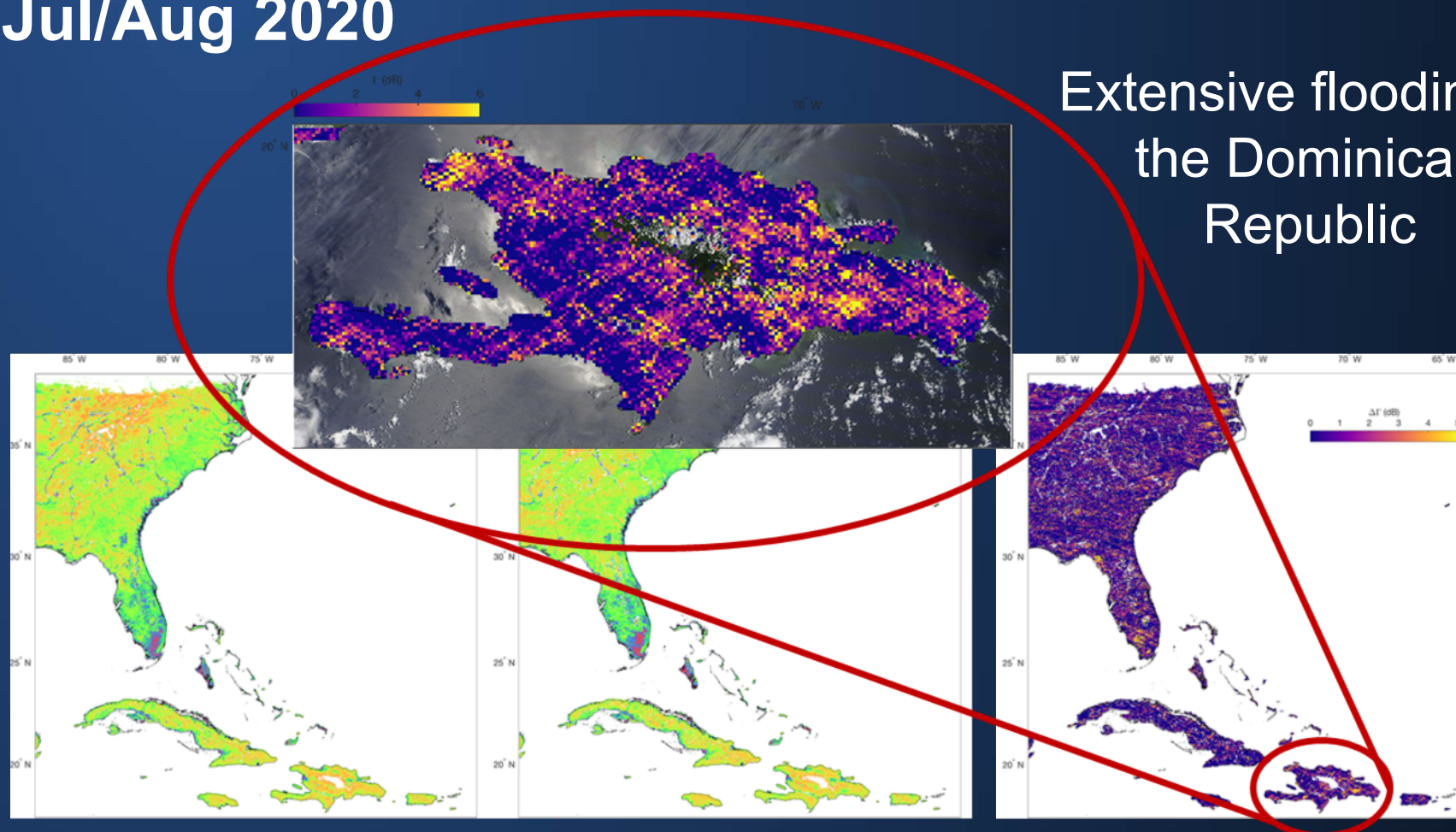


3-hr inner core



Imaging Flooding Inundation after Hurricane Landfall

Reflectivity before and after Hurricane Isaias
landfall, Jul/Aug 2020



Extensive flooding in
the Dominican
Republic

Capability Enhancements Enabled by IIP



- **CYGNSS Receiver Capabilities**
 - GPS L1 C/A signal reception
 - 4 parallel receive channels by digital processor capacity
 - Co-pol only
- **Enhanced Capabilities**
 - Both GPS and Galileo satellites; Both low (L1/E1) and high (L5/E5) bandwidth signals
 - 20 simultaneous channels
 - Co- and X-pol
- **Science Data Product Enhancements**
 - More channels = X4 better temporal and spatial sampling
 - Higher bandwidth = X5 better vertical resolution (altimetry)
 - Dual-pol = Radio Occultation & better vegetation canopy correction

NGRx IIP-16 Project Overview



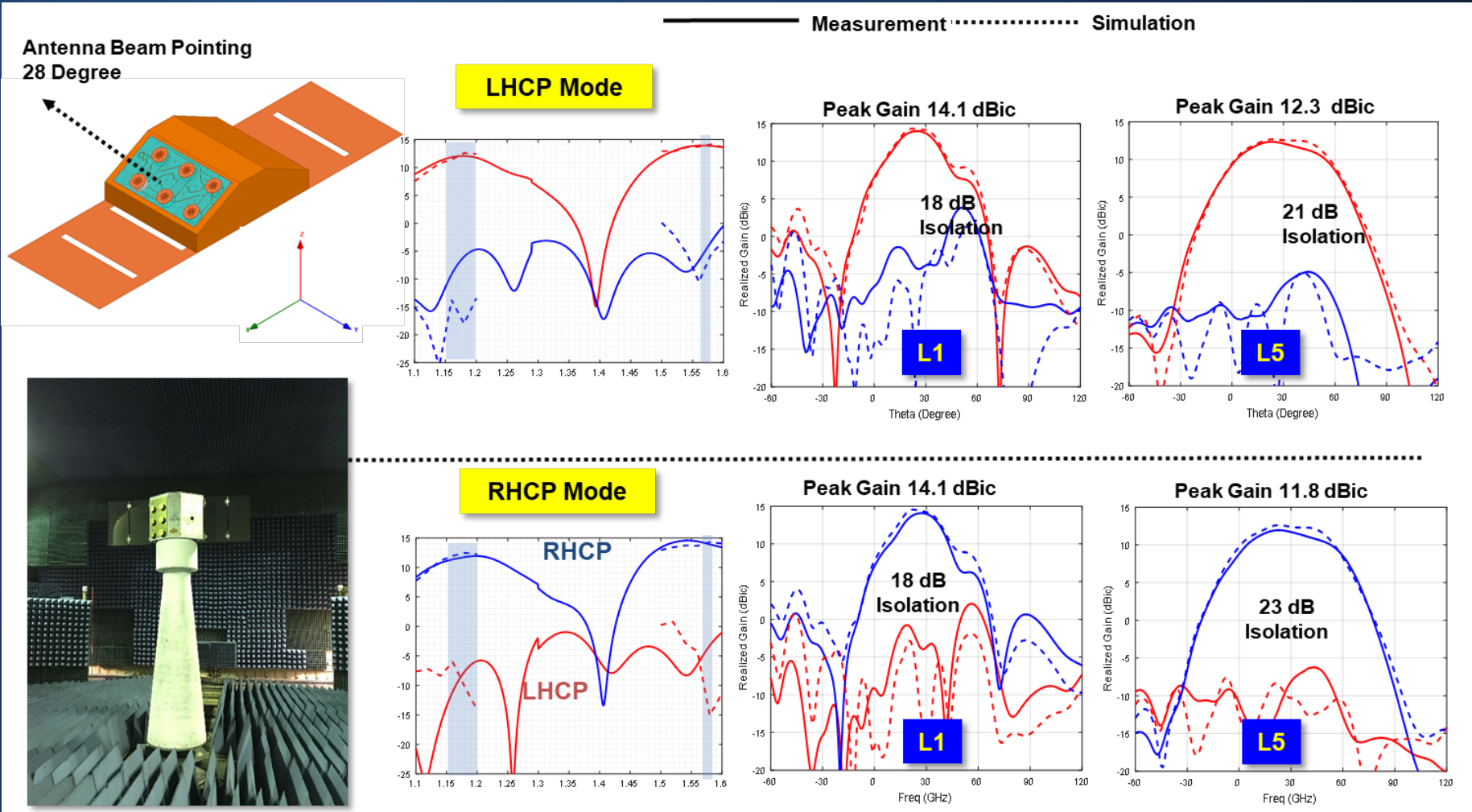
- New antenna design to support Co- and Cross-pol Obs and wider bandwidth for L1/E1 and L5/E5 signal reception
- New front-end RF receiver design to support wider bandwidth for L1/E1 and L5/E5 signal reception
- New back-end digital receiver design to support many signal processing enhancements
- Highly modular system architecture to support variable mission requirements
 - Number of channels, how many L1/E1, how many L5/E5, how many co- or cross-pol, what region(s) of (Delay,Doppler) space to sample

NGRx IIP-16 Project Status



- **Antenna (TRL-6)**
 - Functional and Environmental Testing completed
- **RF Front End (TRL-6)**
 - Functional and Environmental Testing completed
- **Digital Back End (TRL-6)**
 - Functional and Environmental Testing completed
- **Fully Integrated Receiver (TRL-6)**
 - Functional and Environmental Testing completed

Antenna Pattern Chamber Testing



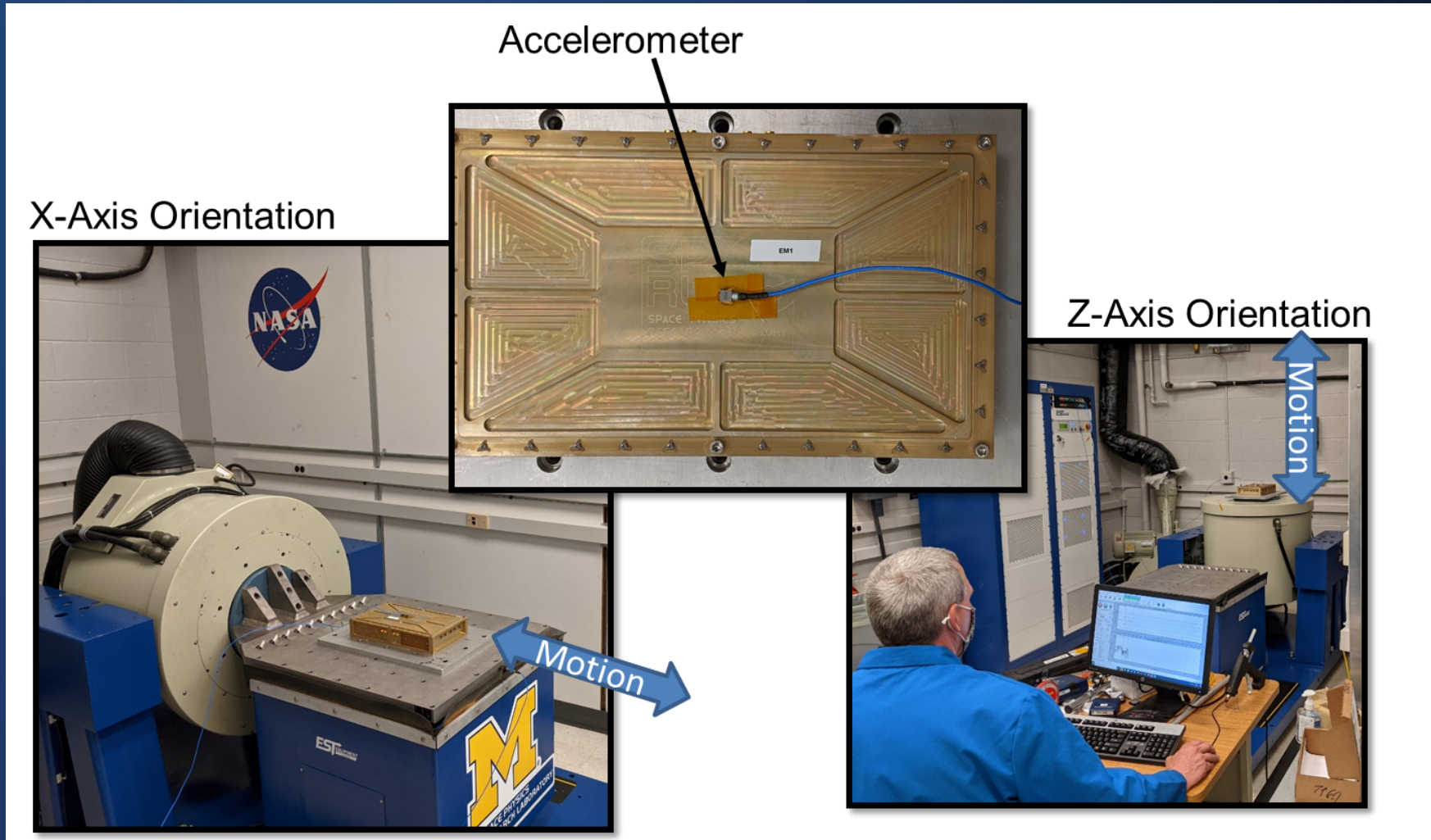
NGRx Integrated Receiver



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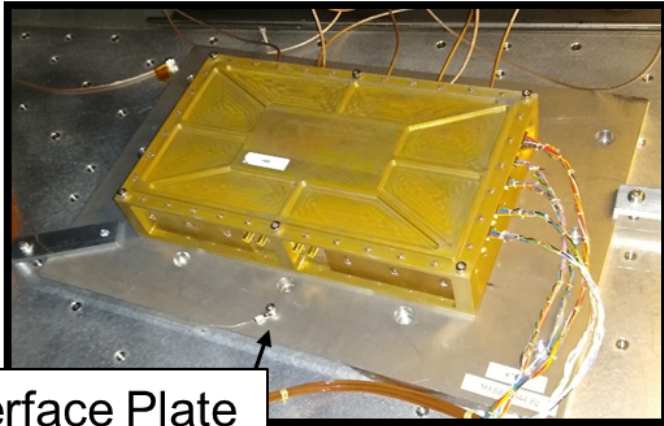
NGRx Vibration Testing



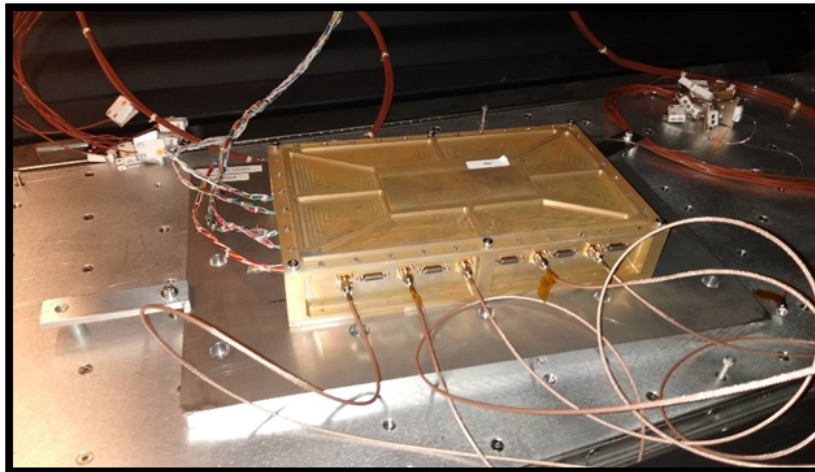
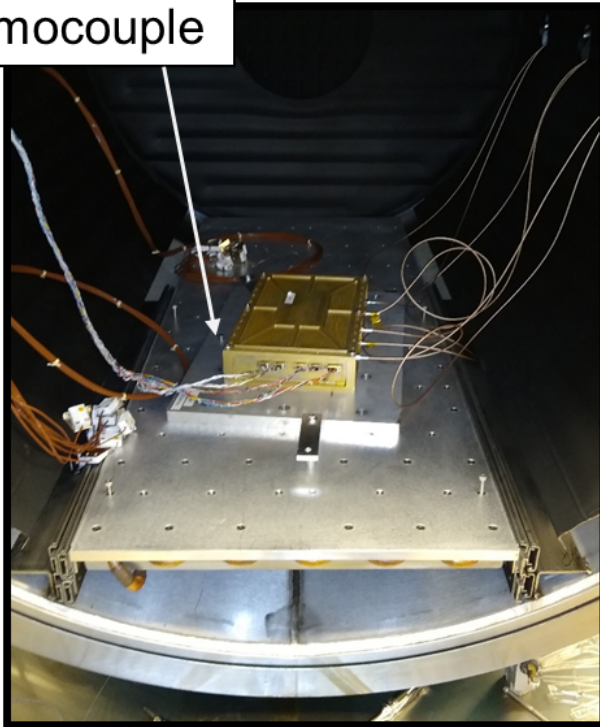
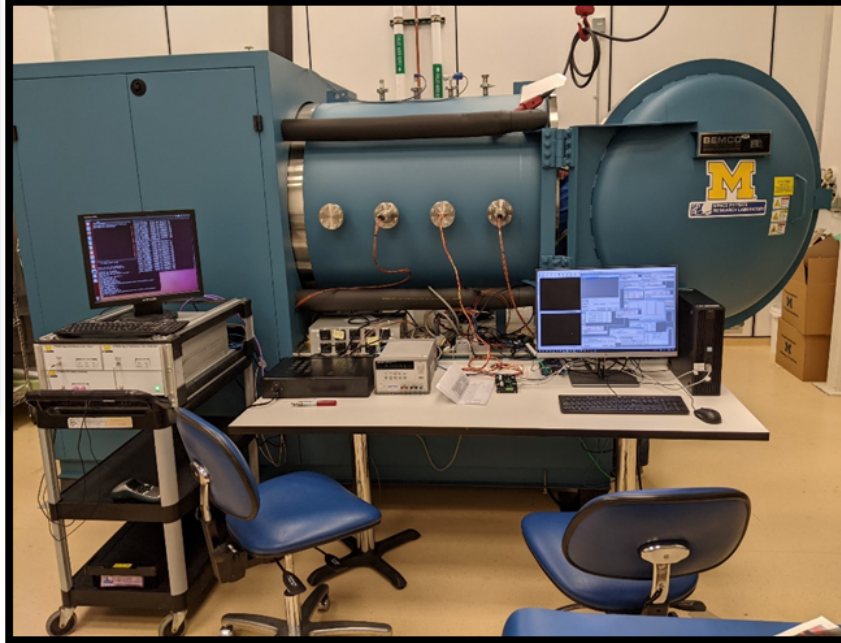
NGRx Thermal/Vacuum Testing



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Interface Plate
Thermocouple



Next Steps



- Several spaceflight opportunities under consideration
- Extended airborne campaign under development in collaboration with the New Zealand Space Agency, Air New Zealand, and the University of Auckland

